

Data Report

Lake Whatcom Residential and Angler Fish Consumption Survey

April 2001



Environmental Health Programs

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Acknowledgements

We wish to thank everyone who supported and participated in the organization, design, and conduct of this study. A special thank you is extended to the Whatcom County Health and Human Services Department for providing staff and helping to organize this study and Lynn Robbins of Western Washington University who provided comments and support. This study could not have been completed without the field assistance of Bernadette Delish, Colin Dietrich, Mary Ann Hollerbeck, Brendan Madden, and Kelsey Rydland; students at Western Washington University. Finally, we wish to acknowledge the Washington State Department of Ecology and the Department of Fish and Wildlife, who provided supporting data and project encouragement.

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Lake Whatcom Fish Consumption Study

Executive Summary

Overview

A survey of Lake Whatcom residents and anglers was conducted between July 21 and July 24, 2000 to gather information on their consumption of Lake Whatcom caught fish, as well as perceptions related to fish advisories. This project was undertaken to gather exposure information for use in assessing the human health implications associated with the consumption of mercury contaminated fish from Lake Whatcom. A retrospective on-site study design with a four-week recall period was selected for this survey effort. The survey study design focused on three populations: residents who lived on or near the Lake or in developments with direct access to the lake, boat anglers accessing the lake at public boat launch facilities, and shore anglers at public access points. This study design was devised in order to maximize the likelihood of gathering representative Lake Whatcom fish consumption information from the surveyed populations. Surveys were conducted through door-to-door interviews, at frequently used boat launch facilities, and at popular shore-fishing locations. Survey efforts focused on the north end of Lake Whatcom, since the majority of residents and potential anglers live and access this section of the lake.

Findings

Descriptive results for the three survey populations (shore anglers, boat anglers, and residents) are summarized below (Table 1). Surveyed shore anglers primarily catch to consume smallmouth bass, cutthroat trout, and perch, while boat anglers reported catching cutthroat trout followed by smallmouth bass. Residential respondents catch, in order of preference, cutthroat trout, followed by smallmouth bass, kokanee, and perch. Crayfish and pumpkinseed were also reportedly consumed by four and one residential respondents, respectively.

Survey results pertaining to fish consumption are summarized below by population (Table 2). Results from this survey suggest that less than two percent of the surveyed residential population had consumed any Lake Whatcom caught fish during the four weeks prior to the survey and that the remainder of the population would consume such fish at a rate less often than one meal per month. Fish consumption data averaged within each of the three survey populations were not significantly different from one another with the exception of the number of fish meals consumed per month. Shore anglers, surveyed primarily at Bloedel Donovan Park, tend to consume Lake Whatcom caught fish more frequently than anglers from the other populations, with nearly half of these respondents having eaten such fish at a rate of one to ten meals (mean=2) during the previous four weeks. Across survey populations, anglers reported eating fish from Lake Whatcom three or fewer months out of the year. Those that are catching and eating fish are primarily the older segment of the population and primarily males. While few fish consuming households contained children, it was reported that younger children (>8 years of age) eat Lake Whatcom caught fish at the same frequency as the adult household members.

During the four-week recall period, survey respondents who consume Lake Whatcom fish also reported consuming canned or fresh tuna at an average rate of one meal per week. While this survey did not gather information on the amount of tuna consumed per meal, the fact that tuna averages 0.17 mg/kg methylmercury (Yess, 1993), suggests that tuna consumption may be a more significant source of mercury

exposure for many local residents due to tuna consumption frequency than the consumption of Lake Whatcom caught fish.

Pertaining to survey results dealing with fish consumption advisory perceptions, nearly 50 percent of respondents (n=21), indicated they would continue eating fish from Lake Whatcom following health recommendations contained in an advisory, 38 percent said they would stop eating Lake Whatcom fish entirely, while 14 percent would continue eating fish unabated. Seventy-five percent of parents with children indicated they would stop feeding their children fish from Lake Whatcom if an advisory were posted.

Conclusions

The small number of anglers and the small proportion of the residential population that actually consumed any Lake Whatcom caught fish during the four week recall period prior to the survey, limited our ability to fully quantify fish consumption characteristics of the local population, especially for women and children. However, these findings indicate that the majority of anglers consume fish from Lake Whatcom at a rate of less than one meal per month and that anglers consume Lake Whatcom caught fish three or fewer months out of the year. This study also identified the presence of a small proportion of anglers that consume fish from Lake Whatcom on a weekly basis and in amounts, which may be sufficient to pose a health risk due to mercury contamination. Assessment of human health concerns associated with mercury in Lake Whatcom fish should also include consideration of canned tuna consumption due to the more frequent consumption of tuna relative to fish caught from Lake Whatcom. While reported fish consumption rates, based on the consumption of locally caught fish, reflect rates constrained by external factors, estimates of consumption based on the fillet photo provide a good upper bound rate estimate for conducting exposure analyses.

Table 1. Survey data and population demographic summary information.

Sample Frame	Survey			Sex (%)		Fishers (%)	Eat Fish (%)	Age Years (%)			
	Attempts	Completed	%	M	F			<18	18-45	46-65	66+
Shore	10	10	100	80	20	100	90	30	50	10	10
Boat	16	16	100	88	12	100	68	0	88	6	6
Residents	386	194	50	45	55	22	11	2	25	42	29
Total	394	220									

Table 2. Fish consumption data summary for anglers who consume Lake Whatcom caught fish.

Sample Population	No. Months/ Yr Fish Eaten (avg ± sd)	No. Years Fish Eaten (avg ± sd)	Typical Fish Meal Size (gms) (avg ± sd)^
Shore (n=7)	2.5±0.6	9±9	249±68
Boat (n=10)	1.9±0.6	13±17	264±39
Residents (n=21)	2.7±1.4	19.5±16.3	225±67

^ Fish meal size based on salmon fillet photo

Abstract

A fish consumption survey was conducted by the Washington State Department of Health on Lake Whatcom, Whatcom County, Washington between July 21 and July 24, 2000. The goal of this survey was to gather information on the consumption of Lake Whatcom caught fish by local residents and anglers in response to preliminary findings of elevated mercury concentrations in some fish species. Surveys of randomly selected residential clusters, and boat and shore anglers, were conducted in person by survey teams using a structured survey instrument. Cutthroat trout and smallmouth bass are the primary species caught and consumed. A small proportion of residential respondents indicated they eat fish from Lake Whatcom ($\cong 11\%$), while less than two percent indicated that they had consumed any of such fish during the four week period prior to the survey. The proportion of surveyed boat and shore anglers who consumed any Lake Whatcom fish during the four weeks prior to the survey was six and forty percent respectively. In general, shore anglers have the greatest intake of Lake Whatcom caught fish due to the frequency of fish meals, although boat anglers typically consume a higher mass of locally caught fish per meal due to the consumption of larger fish. All anglers reported consuming Lake Whatcom caught fish three or fewer months out of the year. When fish catch is not the limiting factor, anglers typically consume about one-half pound of fish per meal. In general, residential and boat anglers consumed tuna four times more frequently than they did fish caught from Lake Whatcom, while shore anglers consumed tuna and Lake Whatcom caught fish at similar frequencies. With regard to angler perceptions and reactions to a theoretical fish advisory, most anglers indicated they would follow the recommendations of the fish advisory.

Introduction

Recent findings by the Washington State Department of Ecology regarding mercury in fish from Lake Whatcom raised concerns by local and state health agencies and prompted a more thorough investigation into contamination levels and human exposure to mercury in these fish. To address questions pertaining to human exposure to mercury in Lake Whatcom caught fish, the Washington State Department of Health, Office of Environmental Health Assessments, in collaboration with the Whatcom County Health and Human Services Department, conducted a survey of Lake Whatcom residents and anglers between July 21 and July 24, 2000. The purpose of this study was to gather baseline quantitative information on the consumption of Lake Whatcom caught fish and tuna by local residents and anglers, as well as qualitative information on their perceptions related to fish advisories in general. Fish consumption information resulting from this study will be used in conjunction with fish tissue mercury data and information on the toxicology of mercury to assess the human health implications associated with the consumption of mercury contaminated fish from Lake Whatcom. This report summarizes the findings from this survey as well as the methods used for data collection and evaluation.

Background

Lake Whatcom is located in the northwest corner of Washington State in Whatcom County at the western edge of the Cascade range foothills (Figure 1). Lake Whatcom is a large body of water extending approximately twelve miles from north to south and covering an area of approximately 4,836 acres. The Lake has three distinct basins separated by glacial sills, with a maximum depth of 328 feet. With its many bays and inlets, Lake Whatcom's perimeter extends approximately twenty-eight miles. In addition to providing sport fishing and recreational opportunities, Lake Whatcom is the source of drinking water for the City of Bellingham and neighboring residents.

Human health concerns over mercury contamination of Lake Whatcom fish were initially raised due to findings from a screening-level fish tissue study by the Washington State Department of Ecology (Ecology) (Serdar et al., 1999). As a result of this study, a single composite sample of eight smallmouth bass (*Micropterus dolomieu*) fillets was found to contain 0.5 mg/kg mercury. Fish tissue mercury concentrations in the range of 0.5 mg/kg were believed to be sufficiently high so as to pose a potential health concern for some segments of the population, depending on the frequency and amount of fish consumed.

To more thoroughly assess the mercury concentration and distribution in Lake Whatcom fish, a comprehensive fish tissue mercury study was undertaken by the Whatcom County Health and Human Services Department and the Washington State Departments of Ecology (Ecology), Health (DOH), and Fish and Wildlife (WDFW). Fish species reported by the WDFW to be caught and consumed from Lake Whatcom (Johnston and Mueller, 2000) were collected from each of the three lake basins. The species included: smallmouth bass (*Micropterus dolomieu*), yellow perch (*Perca flavescens*), kokanee (*Oncorhynchus nerka*), pumpkinseed (*Lepomis gibbosus*), cutthroat trout (*Oncorhynchus clarki*), brown bullhead (*Ameiurus nebulosus*), and signal crayfish (*Pacifastacus leniusculus*). Skin-on fillet samples from each fish were analyzed individually for total mercury. The analysis of individual samples, as compared to composite samples, allows for the determination of mercury concentration variability by species, fish size, and sample collection location. Study details and analytical findings from this effort are

documented in the report “Mercury Concentrations in Edible Muscle of Lake Whatcom Fish” (Serdar et al., 2001).

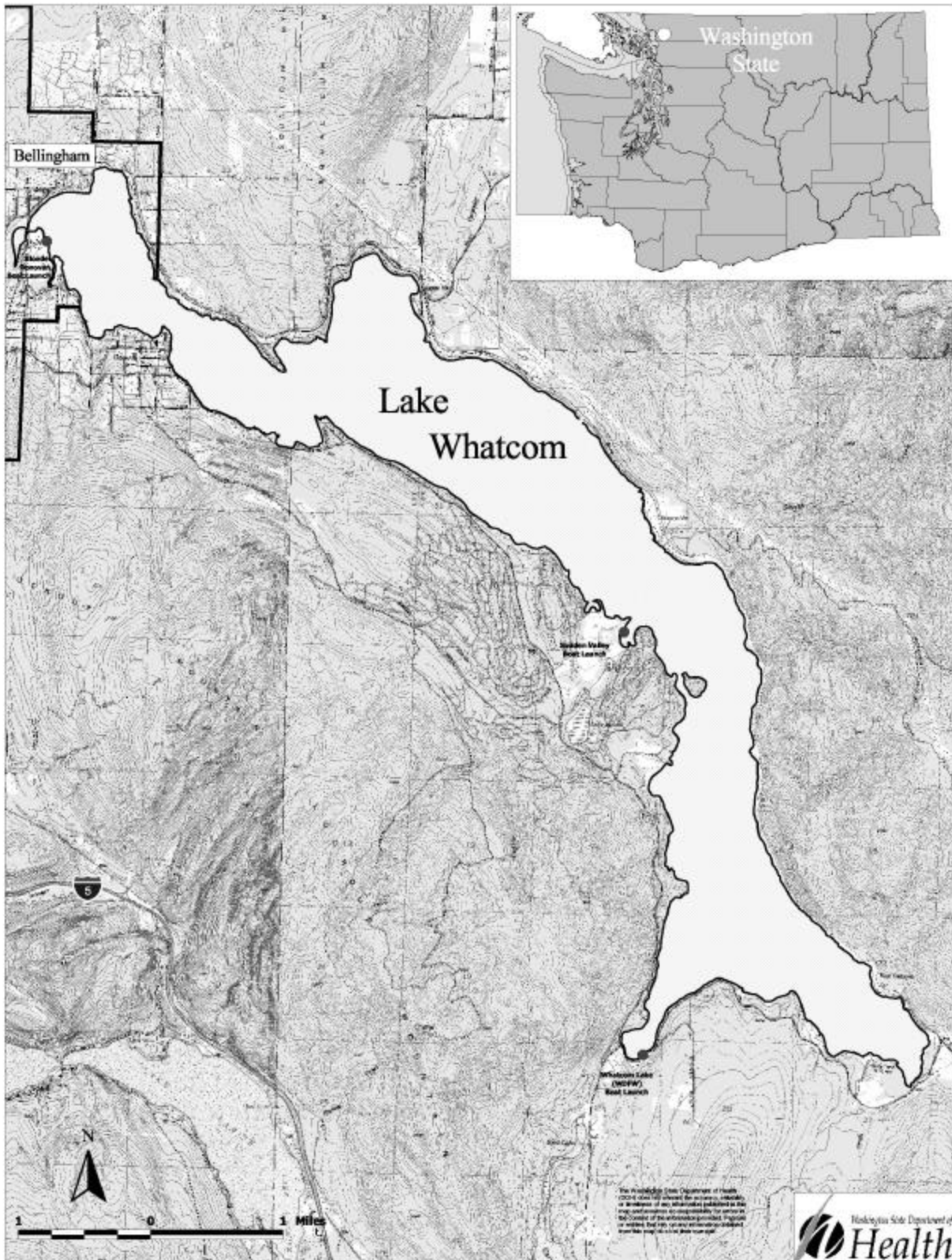


Figure 1 Lake Whatcom Near Bellingham, Washington

Fish consumption information is essential for assessing the human health implications associated with the consumption of chemically contaminated fish (CHEMRISK, 1994; Keenan et al., 1994; EPA, 1997). While fish consumption data have been collected for a number of specific populations and locations in Washington State (Pierce et al., 1981; McCallum, 1985; Landolt et al., 1985 & 1987; CRITFC, 1994; Toy, 1996; DOH, 1997), existing data were not sufficient for characterizing fish consumption by urban residents living on or near a major fresh water lake such as Lake Whatcom. Reliance upon published default consumption values was also not desirable due to the need for greater information specificity, which included information on tuna consumption. To address these data needs, the Washington State Department of Health and the Whatcom County Health and Human Services Department collaborated on a survey to gather local fish consumption information from Lake Whatcom anglers. The goals of this study were:

- To gather reliable information on the consumption of Lake Whatcom caught fish including: the amount, frequency, and species consumed by local residents and area anglers, especially by women of childbearing age and children, which could be used to generate a distribution of mercury intake from Lake Whatcom fish,
- To gather information regarding these respondents' perceptions and likely reactions to a fish consumption advisory, and
- To gather information on the frequency of tuna consumption as well as demographic information on the surveyed population.

Methods

Study Design

Rather than collecting information from a single sample of all local residents, the survey study design focused on three target populations: residents who lived on the Lake's shore or in developments with direct access to the lake, boat anglers accessing the Lake through public or private boat launches, and anglers using public access points for shore fishing. It was presumed that fishing practices and Lake Whatcom fish consumption characteristics would vary among target populations. By differentiating these target populations, the survey had a high probability of including Lake Whatcom fish consumers. A cross-sectional sample from each of these target populations was selected as described below. Face-to-face interviews were conducted using a structured instrument to collect fishing and detailed fish consumption data from surveyed individuals as well as for other household members.

A four-week recall period was chosen for the collection of Lake Whatcom angler fish consumption information in order to minimize recall error (Eisenhower et al., 1991). The four-week recall period reflects a compromise between recall accuracy, ability to discern variation over time, and the efficient use of limited resources. While shorter recall periods result in more accurate recall information, consumption of specific species of fish taken from a specific location can be quite low and variable, leading to recall estimates with an extremely high variance. Extending the recall period to four weeks was expected to reduce this source of variability. A four-week recall period also reflects a toxicologically relevant exposure duration, reflecting two to four times the interval over which fish consumption can reasonably be averaged with regard to mercury exposure and toxicity.

Selection of the Residential Sample

Initial planning focused on the north end of Lake Whatcom, where the vast majority of Lake Whatcom residents live, for survey data collection. The private community of Sudden Valley was initially targeted for inclusion in the survey, however residential surveying was prohibited by the homeowners association (D. Olson, personal communication). Based on land parcel geographic information system (GIS) coverages provided by the Whatcom County Assessors Office (Judge, 2000) a total of approximately 1000 shore-side or near-shore residences with private or communal lake access were identified on the north end of Lake Whatcom for inclusion in the survey, excluding Sudden Valley residences.

During preliminary visits to the survey area, it was noted that the general age and size of homes, and therefore the value of the homes, appeared to vary greatly between locales. Based upon apparent differences in home value as a surrogate indicator of resident lifestyle differences between locales, it was postulated that fishing and fish consumption behaviors of residents might also vary between these locales. To address this possibility, a two-stage sampling design was developed to increase the efficiency of sampling. Through field observations, sixteen residential clusters were identified (Figure 2). Residential clusters were defined based on age of neighborhoods, multi-family vs. single family housing types, and neighborhoods with direct private access to the Lake-shoreline vs. neighborhoods with community beach access. These clusters were stratified into five neighborhood types or strata: 1) high density (i.e., apartments/condominiums), 2) older single family residences/cabins with individual lake frontage, 3) modern single family residences with individual lake frontage, 4) new single family residences with individual lake frontage, and 5) modern single family residences with community lake access. Clusters contained approximately 40-80 residences of similar characteristics. Clusters were randomly selected from each strata (Table 1). The probability of selection varied across strata, as there were different numbers of clusters per stratum. All residences within the selected clusters were included in the survey.

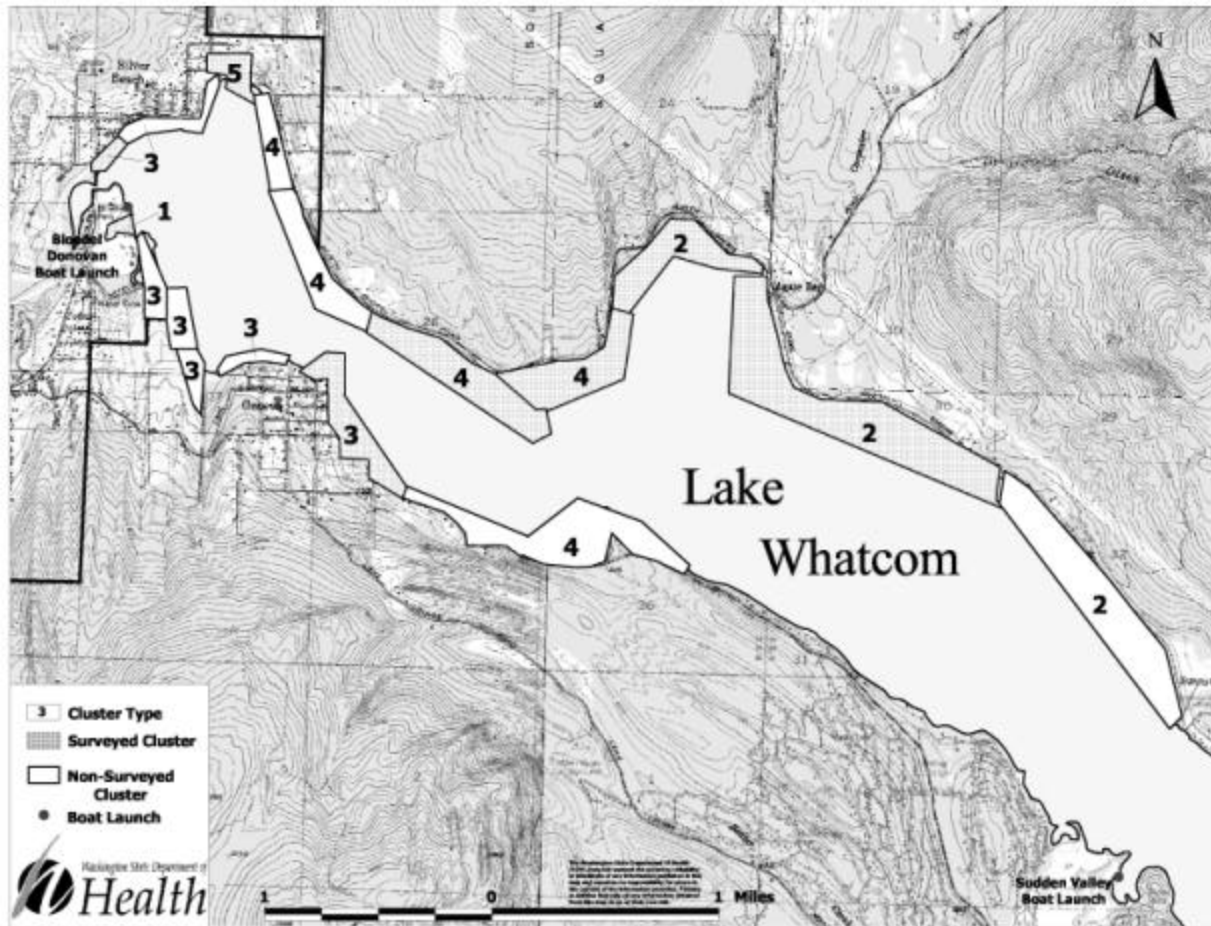


Figure 2. Lake Whatcom Fish Consumption Survey Residential Clusters and Surveyed Boat Launches

Boat and shore angler sampling

Lake Whatcom has two public boat launches and a private launch serving Sudden Valley, a large private development. Interviews were conducted at the boat launch facilities located at Bloedel Donovan Park and at Sudden Valley. These two boat launch facilities were reported by the Washington State Department of Fish and Wildlife as well as by Whatcom County staff to be frequently used, while the third boat launch, located on the south end of the lake, was reportedly seldom used and therefore not surveyed. Popular shore fishing locations targeted for surveying included the children's fishing pond in Whatcom Falls Park and the bridge at the outlet of Lake Whatcom near Bloedel Donovan Park. Surveys were conducted at boat launch facilities between 7:00 and 9:00 AM and between 7:00 and 9:00 PM on the three study days. Shore fishing locations were visited numerous times during the survey day by roving survey support staff.

Interviewer Training

The interviewers consisted of six students from Western Washington University, three staff from the DOH, and two staff from Whatcom County Health and Human Services Department. Two, two-hour interviewer survey training sessions covering the survey purpose, use of the survey instrument, the

importance of accurate data collection, and survey logistics, were held prior to the start of the survey. Students were accompanied and supervised during the first day of the survey and demonstrated their ability to competently administer the survey.

Data Collection

Door-to-door interviews of lake-shore residents were conducted by survey teams of two interviewers within randomly selected residential clusters. Teams were assigned a cluster and approached every house in that cluster. Houses where no one was home were revisited later that day or on the following day. Residences with signs indicating that they did not want to be disturbed, or where unrestrained dogs or other hazards existed, were classified as refusals. The person typically responsible for cooking for the household was interviewed if he/she was available due to their improved recall of family dietary habits, especially that of children (Nelson et. al., 1990).

To gather information on the consumption of Lake Whatcom caught fish from boating anglers, morning and evening surveillance was conducted during the survey time frame at the Bloedel Donovan Park boat launch and the boat launch in Sudden Valley (Figure 2). All boating parties entering or leaving the water at these two boat launches were approached. Upon initial contact, the number of anglers in the fishing party was recorded and a general question was directed to each angler asking whether they eat the fish they catch from Lake Whatcom. From those in the group that indicated they eat the fish, a single individual was selected for interviewing due to time constraints and due to interviewer inability to spatially separate anglers so as to obtain unbiased responses. The selected angler was then asked detailed questions regarding their consumption of Lake Whatcom caught fish, their consumption of tuna, and finally questions pertaining to their demographic characteristics. Women were preferentially targeted for interviewing due to the toxicology of mercury in fish (i.e., potential adverse health effects of mercury on fetal development), and due to their generally greater awareness of foods eaten in the home. All observed shore anglers were surveyed regarding their consumption of Lake Whatcom fish.

All interviews were conducted in person by trained interviewers using a structured survey instrument. Questionnaires included questions regarding demographic characteristics, frequency of fishing, species-specific consumption frequency, amount and duration of adult fish consumption, consumption by children (residential survey), and perceptions regarding behavioral change associated with a theoretical fish consumption advisory. Detailed fish consumption questions were only asked of individuals who responded positively to an initial question regarding their consumption of Lake Whatcom caught fish. Color photographs of popular Lake Whatcom caught fish species, as contained in the WDFW fishing regulations booklet (WDFW, 2000), were used to minimize species miss-classification.

To quantify the amount of fish typically eaten during a fish meal, respondents who indicated they consume fish from Lake Whatcom, were shown a scaled full color photograph of a salmon fillet on a plate, and asked how much of the fillet pictured they would typically eat during a fish meal (Appendix B). While the size of fish, depicted by the partial fillet photo was not typical of fish caught from Lake Whatcom, it did provide an easily identifiable metric for quantifying the amount of fish mass typically consumed per fish meal when catch was not the limiting factor. Responses to this question were recorded in terms of inches of fish fillet according to the photo scale-bar.

After preparing the initial fillet photograph, the fillet was cut along one inch transects and each slice weighed to the nearest tenth of a gram using an Acculab[®] VI – 10kg scale in order to establish a correlation between fillet volume, as depicted by the photograph and fillet mass. Using this information,

the mass (grams) of fish tissue typically consumed per meal could be estimated from an individual's response.

While fish consumption questions were asked only of survey participants who indicated that they or a member of their family eat fish caught from Lake Whatcom, demographic information was requested of both consumers and non-consumers of Lake Whatcom fish at the completion of the survey. Demographic information collected for statistical purposes included: age by category, number of persons and the number of women between the ages of 18-45 years living at the residence, race and sex.

Data Reduction and Analysis

Survey data were entered into a Microsoft Access[®] database. A data entry screen, similar in appearance to the actual survey form, was developed to improve data entry efficiency and quality. Survey forms were labeled with a three-digit sequential unique identification number. This number was also assigned to the record in the database, ensuring that surveys would not be entered twice into the database and allowed for Quality Assurance/Quality Control (QA/QC) checking of database entries. Upon completion of initial data entry, all records underwent a QA/QC check through data re-entry and review. Data tabulation and statistical analyses were conducted using STATA[®] software (College Station, TX).

Survey Results

Results from this survey are initially presented separately for each of the three survey samples. Results from aggregated survey data are then described.

Residential Sample

A total of 194 residential interviews were completed out of 386 survey attempts for a 50% response rate. Of the 192 failed survey attempts, only 19 were refusals; in the remaining 173 cases there was no one at home at the time of the initial contact or during subsequent visits (Table 1). Response rates ranged from a low of 40 percent for strata one, which consisted of a high density apartment neighborhood, to a high of 64 percent for strata five, which consisted of modern individual residences with shared community lake access.

Table 1. Residential Survey Interview Summary

(Strata) Description	# Clusters Surveyed Out of Total	Survey Interviews (n)			% Completed
		Attempts	Refusals	Completed	
(1) High Density, Shared	1/1	111	4	44	40
(2) Older, Lake Frontage	2/3	87	13	49	56
(3) Modern, Lake Frontage	2/7	73	0	43	59
(4) New, Lake Frontage	2/4	79	2	35	44
(5) Modern, Shared Access	1/1	36	0	23	64
Total	8/16	386	19	194	50

Demographic Characteristics

Slightly more females were interviewed than males (55% vs. 45%). The vast majority of survey respondents were Caucasian (90%), with 42 percent between 46 and 65 years of age, and more than 71 percent of respondents 46 years of age or older (Table 2). Stratum four varied slightly from the other strata with regard to age distribution in that 91 percent of respondents were 46 year of age or older and only nine percent self reported to be in the 18 to 45 year old age bracket. Other demographic characteristics were generally similar between strata.

Table 2. Residential Respondent Demographic Characteristics

	Overall (%)	Strata				
		1	2	3	4	5
Gender (%)* (n=192)						
Male	45	36	53	38	57	41
Female	55	64	47	62	43	59
Age (%)* (n=192)						
<18	2	-	-	5	-	5
18 - 45	25	34	20	30	9	32
46 – 65	42	23	51	35	59	45
66+	29	39	24	26	32	18
Refused	3	5	4	5	-	-
Race (%)* (n=193)						
Caucasian	90	86	92	95	89	82
Hispanic	1	-	2	2	-	-
Native American	.5	-	2	-	-	-
Asian	.5	-	-	-	-	5
Other	4	5	-	-	11	9
Refused	4	9	4	2	-	5

* Percentages may not add up to 100% due to rounding.

Fish Consumption

Twenty-two percent of residential survey respondents (n=42) indicated they or a member of their family had fished on Lake Whatcom, while eleven percent of respondents (n=22) reported that they or a member of their family eats fish caught from Lake Whatcom (Table 3). The percentage of respondents that fish Lake Whatcom and eat the fish they catch, varied between strata. When asked about how long they have been fishing and eating fish from Lake Whatcom, respondents indicated doing so for an average of 19.5 years (n=22, sd=16.3).

Table 3. Lake Whatcom Fishers and Fish Consumers By Residential Strata

Strata	Households That Fish Lake Whatcom		Households That Eat Lake Whatcom Fish		No. Years L.W. Fish Have Been Eaten (mean±sd)
	No.	% of Surveyed	No.	% of Surveyed	
1	5	11	4*	9	10.5±12.2
2	13	27	7*	14	29.4±21.8

3	12	28	5	12	14.4±7.0
4	5	14	1	3	20
5	7	30	5	22	18±15.5
Total	42	22	22	11	19.5±16.3

*Includes one respondent that eats Lake Whatcom fish, but does not go fishing

To more fully enumerate the Lake Whatcom fish consuming population for the surveyed clusters, respondents were asked about whom else in the household eats Lake Whatcom caught fish. In addition to respondents (men, n=13 and women, n=9), surveyed households contained an additional 17 men, 6 women (18-45 y/o), 6 women (>45 y/o), and 10 children.

The proportion of the surveyed population within each stratum that consumes fish from Lake Whatcom ranged from 2.4 percent in stratum four, which consisted of new single family lake front homes, to 26 percent for stratum five, modern single family homes with shared community lake access. The proportion of residents that consume Lake Whatcom fish was similar in stratum one and two (12 percent), and only slightly greater in stratum three (15 percent). Overall, an estimated 12 percent of the surveyed residential population consumed fish from Lake Whatcom.

Respondents who indicated that they consume Lake Whatcom caught fish (n=22), were asked detailed questions about their fish consumption habits, even though they may not have eaten any of such fish during the past four weeks (Table 4). The most commonly consumed Lake Whatcom caught fish specie was cutthroat trout (n=14), followed by kokanee (n=10), smallmouth bass (n=9), perch (n=6), and crayfish (n=4). Pumpkinseed and brown bullhead were each reportedly consumed by single respondents. The mean number of fish typically eaten per meal varied by species, with respondents generally consuming greater numbers of smaller fish species per meal. Lake Whatcom caught fish are generally consumed three or fewer months per year.

Only three respondents, two men and one woman, reported eating fish from Lake Whatcom during the four-week recall period prior to the survey. One respondent reported eating one meal of cutthroat trout, the second respondent reported three meals of kokanee, and the last reported eating two meals of Lake Whatcom caught fish, one of kokanee and one of smallmouth bass.

Table 4. Residential Sample Fish Consumption By Species

Species	No. Fish Eaten Per Meal		No. Months Per Year Fish Eaten	
	Mean	Range	Mean	Range
Cutthroat Trout (n=14)	1.7	1 - 3	2.6	1 – 6
Kokanee (n=10)	1.7	0.5 – 3.5	2.4	1 – 6
Perch (n=6)	5.1	1 - 11	3.0	1 – 5
Smallmouth Bass (n=9)	1.8	1 – 4.5	2.6	1 – 4
Crayfish (n=4)	10.9	1 - 30	3.0	2 – 4

To assess whether fish consumption practices during the survey recall time frame were representative of fish consumption practices throughout the fishing season, respondents were asked if there was another time of year when they eat Lake Whatcom caught fish more frequently. Fourteen of the twenty-two respondents (64%) reported eating Lake Whatcom caught fish more frequently during some other time of

the year, however, there was no clear pattern in the responses. Respondents indicated that Lake Whatcom caught fish are primarily consumed between the months of April and September, with “summer” being the most frequently provided response (n=4).

The average amount of fish consumed by adults during a typical meal, estimated using salmon fillet photo described above, was 225 grams (sd=67) with meal sizes ranging from 65 to 301 grams. Men (n=12) reportedly consume on average 237 grams per meal (sd=55), which was slightly more than the amount reported by women (n=9) (mean=209, sd=81), although not significantly different.

Gathering information on the consumption of Lake Whatcom fish by children (< 18 y/o) was of particular interest in the design and conduct of this survey. Five of the surveyed fish consuming households also contained children (n=10), who ranged in age from two to seventeen years with a median age of 13.5 years. Six of nine of these children were males. Children reportedly ate the same fish species as their

parents, while none had consumed Lake Whatcom caught fish during the past four weeks. The amount of fish consumed per meal, based on the salmon fillet photo described above, ranged from 99 grams to 265 grams for children eight to seventeen years of age, with a median consumption of 131 grams per meal.

Consumption of Canned Tuna

Respondents who consume Lake Whatcom fish were also asked about the number of times they consumed canned or fresh tuna during the past four weeks. Respondents (n=19) consumed tuna an average of 4.2 times, with individual consumption ranging from one to twenty-eight times during the prior four weeks. Men (n=12) and women (n=7) both reported a median tuna consumption of 2 meals during the four week period, with tuna consumption by men ranging from one to twenty-eight meals (mean=5; sd=7.6), while consumption by women ranged from one to six meals (mean=3; sd=1.7).

Response to Health Advisories

To assess public perceptions related to health advisories for contaminated fish, three questions were asked pertaining to a hypothetical fish consumption advisory. The first focused on feeding children fish from a posted water body, the second question focused on adult consumption of fish from a posted water body, and the third focused on the best ways to communicate advisory recommendations. Regarding the hypothetical advisory, three of four respondents with children stated they would stop feeding their children any fish from Lake Whatcom. The fourth respondent indicated they would continue to feed their child Lake Whatcom fish, but that they would follow the recommendations of the advisory. Nearly half of the adults (10/21) indicated they would continue eating fish from Lake Whatcom following the recommendations in the advisory, while 38 percent (n=8) indicated they would stop eating any Lake Whatcom fish, and the remainder of respondents (n=3) would continue eating Lake Whatcom fish unabated. Lake Whatcom fish consumers were asked to indicate their preferred method(s) for receiving advisory information. Responses in order of declining preference were: newspaper, radio, signs, and in the fishing regulations booklet.

Boat Angler Sample

As a result of morning and evening boat launch surveillance, sixteen boat angling parties were contacted; fifteen at the Bloedel Donovan Park boat launch and one at the Sudden Valley boat launch. The median

fishing party size was two persons, while a total of 38 anglers were represented overall. Of these anglers, 71 percent (n=27) reported eating at least some of the fish they catch from Lake Whatcom.

Descriptive Characteristics

Responses from the detailed surveys (n=16) revealed that most surveyed anglers were male (88 percent), of Caucasian race (88 percent), and between the ages of 18 and 45 years (88 percent). Three of the sixteen anglers surveyed reported that this was their first time fishing on Lake Whatcom. Of the surveyed anglers who repeatedly fish Lake Whatcom (n=12), over half did so less than once per month, while the upper quartile of anglers reported fishing on the Lake an average of nine times per month (sd=7). When returning anglers were asked about the number of years they have fished on Lake Whatcom, responses ranged from one to sixty years with a median duration of six years. While six anglers responded that they eat Lake Whatcom fish more frequently during a particular time of year, no particular season was more frequently identified than any other. The majority of surveyed boat anglers (82%) lived in western Whatcom County in the vicinity of Lake Whatcom.

Fish Consumption

Surveyed boat anglers (n=9) reported consuming cutthroat trout (n=6), smallmouth bass (n=4), crayfish (n=1), kokanee (n=1), and perch (n=1). Anglers who consume cutthroat trout reported eating either one or two fish per meal (mean=1.4) and consumers of smallmouth bass reported eating one to four fish per meal (mean=2). Cutthroat trout and smallmouth bass were consumed three or fewer months per year. Regardless of species, 78 percent of surveyed anglers consumed Lake Whatcom species two or fewer months per year. Only one of the anglers interviewed reported consuming any Lake Whatcom fish during the prior four week period, even though that angler reported fishing on Lake Whatcom an average of 4.3 times per month.

To quantify the amount of fish an angler typically consumes per meal, surveyed anglers who reported eating Lake Whatcom fish were shown the fillet photo described previously, and asked about how much of this fillet they eat during a typical fish meal. The reported amount of fish consumed per typical fish meal by these anglers (n=10) ranged from 186 grams to 301 grams, with an average meals size of 264 grams (sd=39) i.e., slightly greater than one half pound of fish per meal. Six of the sixteen surveyed anglers reported having eaten fresh or canned tuna during the four week survey recall period at frequencies ranging from one to eight times (mean=3.3, sd=2.9).

When these anglers were asked how they would respond to a hypothetical health advisory for a particular species of fish, a majority of anglers (62 percent) indicated they would continue to eat the fish, making sure to follow the recommendation contained in the advisory, while 31 percent indicated they would stop eating any fish from that location. Preferred methods, in declining order, of communicating advisory information were: posted signs, newspaper, fishing regulations, and radio.

Shore Angler Sample

Descriptive Characteristics

Ten shore anglers were interviewed during random visits to popular shore fishing locations over the three survey days. All observed anglers were approached and at least one angler in each party was

interviewed. A majority of the anglers ($n=7$) were interviewed while fishing at or near the Whatcom Creek bridge at the north end of Lake Whatcom. Two anglers were interviewed while fishing at the youth fishing pond adjacent to Whatcom Creek. One male angler was also interviewed while fishing from the shore at Sudden Valley. Three of the anglers interviewed were less than eighteen years of age, while five were 18-45 years of age. Nine out of ten anglers reported that they or household members eat fish from Lake Whatcom, while three anglers reported this to be their first time fishing on Lake Whatcom or adjacent waters. Eight of ten interviewed anglers were Caucasian, and two anglers were African-American.

Fish Consumption

Lake Whatcom shore anglers who repeatedly fish the lake ($n=7$) did so an average of 8.4 times per month ($sd=5.1$), and had been doing so an average of nine years ($sd=9.1$). The estimated typical amount of fish anglers eat per meal, based on the fish fillet photograph, ranged from 131 grams to 301 grams ($mean=249$). Four anglers also reported consuming canned or fresh tuna between two and five times during the previous four week period ($mean=4.0$, $sd=1.4$).

Lake Whatcom shore anglers ($n=7$) reported catching and consuming the following species: smallmouth bass ($n=7$), cutthroat trout ($n=5$), perch ($n=4$), and pumpkinseed ($n=1$). These anglers reported consuming an average of 1.1 ($sd=.55$) trout, 1.3 ($sd=.49$) bass, or 2.3 ($sd=1.3$) perch per fish meal. All species were reportedly consumed two to three months out of the year.

During the four weeks prior to the survey, four of ten interviewed anglers reported having eaten fish from Lake Whatcom, with the reported number of fish meals ranging from 1 to 10 ($mean=4.0$). These respondents reported consuming an average of 2.4 meals of smallmouth bass. Perch were eaten by two anglers at one and two meals respectively, while cutthroat trout and pumpkinseed were each eaten by one angler during the four week recall period. One respondent reported consuming four meals of Lake Whatcom caught fish and five meals of tuna during the previous four week recall period.

In response to the question pertaining to a hypothetical advisory for a particular fish species, five of seven interviewed anglers reported that they would continue eating fish from Lake Whatcom, making sure to follow the recommendations contained in the advisory, while the other two anglers reported that they would stop eating any fish from Lake Whatcom. In response to questions pertaining to dissemination of fish consumption advisory information, preferred methods in declining order of preference were: newspaper, posted signs, regulation booklet, and radio.

Estimation of Total Population Consuming Lake Whatcom Fish

Stratum-specific population estimates were calculated using the number of households in each stratum and the mean number of persons per household in each stratum. Parcel data provided by the Whatcom County Assessors Office (Judge, 2000) were used to determine the total number of households by stratum within the survey area. The mean number of persons per household varied from 1.55 (± 0.21 , 95% C.I.) to 3.13 (± 0.62) between sample strata (Table 5). The weighted average household population across surveyed clusters is estimated to be 2.66 (± 0.60) persons. Weighting accounts for the probability of selecting a particular cluster within a particular cluster type. The total population of surveyed clusters is estimated to be 503 persons of which 61 persons (12%) are likely to consume fish from Lake Whatcom.

Of this population, 49% were reported to be males over eighteen years of age, 23% were reported to be women over 45 years of age, 17% were children 18 years of age or younger, and 11.5% were women between the ages of 18 and 45 years.

Table 5. Residential Lake Whatcom Fish Consumer Population Estimates

Strata	No. Surveyed Households*	Persons Per Household Mean (\pm CI 95%)	Surveyed Cluster Population	Res. Fish Eaters # (%)	Total No. Households In Study Area	Est. Study Area Population	Est. No. LW Fish Eaters
1	44	1.55 (0.21)	68	8 (12)	111	172	20
2	47	2.34 (0.30)	110	13 (12)	130	304	36
3	40	3.15 (0.44)	126	19 (15)	457	1440	217
4	35	2.43 (0.35)	85	2 (2.4)	263	639	15
5	23	3.13 (0.62)	72	19 (26)	42	131	35
Total (w)	189	2.66 (0.60)	503	61 (12)	1003	2668	320

* Excludes five households which did not provide residence population information.

(w) Weighted values based on probability of cluster selection within a particular cluster type.

Population estimates and fish consumer counts from the surveyed clusters were used to estimate the population and number of Lake Whatcom fish consumers for the entire study area, i.e. the northwest end of Lake Whatcom (Table 5). Based on proportion estimates from the surveyed clusters, the population of Lake Whatcom fish consumers was estimated for the study area. The surveyed area represents a population of approximately 2668 persons, of which 320 persons are estimated to consume fish caught from Lake Whatcom.

Calculation of Fish Consumption Rates

To evaluate the amount of Lake Whatcom fish tissue consumed by residents, the number of fish of each species reportedly consumed at a typical meal was combined with fillet weight data gathered as part of the recent Lake Whatcom mercury study (Serdar et al., 2001). First, specie-specific mean fillet weights were calculated using data from all fish caught (Table 6). These fish were obtained through electro-shocking so the sample included fish of all sizes present in the lake. To correct for a potential downward bias which might occur as a result of anglers not keeping small fish, specie-specific mean fillet weights were calculated using only the largest 80% of fish of each specie. While no Lake Whatcom angler catch or creel data are available to support the assumption that smaller fish are not kept, the net result is an increase in the mean fillet weight of 5-18% across species. The mean fillet weight for the two most commonly consumed species, smallmouth bass and cutthroat trout, increased 15 and 16 percent, respectively.

Table 6. Lake Whatcom Fish Species Fillet Weights.

Fish Species	All Fish		Larger fish (excludes lower 20%)		Avg. Fillet Wt. Change (%)
	Sample Size	Fillet Wt. Mean \pm sd (gms)	Sample Size	Fillet Wt. Mean \pm sd (gms)	
Brown Bullhead	13	67.9 \pm 45.7	11	75.9 \pm 45.2	12
Crayfish	45	3.7 \pm 1.4	37	3.9 \pm 1.4	5
Cutthroat Trout	30	36.5 \pm 32.6	24	42.4 \pm 33.9	16
Kokanee	30	25.2 \pm 6.8	24	26.6 \pm 6.6	6
Pumpkinseed	30	15.9 \pm 8.9	24	18.3 \pm 8.3	15
Smallmouth Bass	95	190.9 \pm 108	76	219.8 \pm 102	15
Yellow Perch	30	42.1 \pm 45.6	24	49.7 \pm 48.1	18

Data from the residential (n=20), boat (n=9), and shore (n=8) surveys regarding the number of fish typically consumed at a meal were multiplied by the mean fillet weight data from the largest 80 percentile of fish caught, in order to estimate the amount of fish of each species consumed during a typical meal (Table 7). Survey catch data are assumed to reflect typical fish consumption patterns, since survey results indicate that fish catch and consumption is greatest during the summer months (i.e., when the survey was conducted). Lake Whatcom fish consumers from the residential sample generally consume a wider variety of fish species than do boat or shore anglers. Regardless of target population, anglers who consume smallmouth bass generally consume more smallmouth bass per meal than any of the other commonly caught fish species. Of the fish species commonly consumed from Lake Whatcom, responses indicate that cutthroat trout are consumed by more anglers than the other species, although the amount of cutthroat trout consumed per meal is less than the amount of yellow perch or smallmouth bass consumed during a fish meal.

Table 7. Estimated Species-specific Fish Meal Sizes For Commonly Caught and Consumed Lake Whatcom Fish Species.

Sample Species	Crayfish	Cutthroat Trout	Kokanee	Yellow Perch	Smallmouth Bass
Residential Sample					
Sample Size (n)	4	14	10	6	9
Fish Meal Size Median (gms/meal) IQR	24 (11 – 74)	53 (42 – 106)	40 (27 – 66)	162 (99 – 497)	220 (220 – 440)
Boat Angler Sample					
Sample Size (n)	-	6	-	-	4
Fish Meal Size Median (gms/meal) IQR	-	53 (42 – 85)	-	-	330 (220 – 659)
Shore Angler Sample					
Sample Size (n)	-	5	-	4	7
Fish Meal Size Median (gms/meal) IQR	-	42 (42 – 42)	-	99 (75 – 149)	220 (220 – 440)

IQR – Inner Quartile Range i.e., 25th – 75th percentile

Conclusions

This study was undertaken to gather quantitative information on the catch and consumption of fish from Lake Whatcom by near-shore residents, boat anglers and shore anglers, for use in assessing the human health implications of mercury in various fish species. Lack of existing fish consumption information from a similar urbanized lake in Washington necessitated this study. While the shore angler and boat-angler samples specifically targeted individuals who were catching fish from Lake Whatcom, the residential sample targeted the shoreline residential population, which included anglers as well as non-anglers.

Early in the assessment process, anecdotal reports suggested that Lake Whatcom supported a sizable recreational fishery with anglers frequently consuming a wide variety of fish species including crayfish. Information gathered from this study supports these reports, however, the number of persons that fish Lake Whatcom is but a small proportion of the local population, with the proportion that consumes fish from Lake Whatcom being even smaller. Results from this survey suggest that less than two percent of the surveyed residential population had consumed any Lake Whatcom caught fish during the four weeks prior to the survey and that the remainder of the population would consume such fish at a rate less often than one meal per month. Of the three target populations, shore anglers consume Lake Whatcom caught fish most frequently, with nearly half of these respondents having eaten such fish during the previous four weeks. Across survey populations, anglers reported eating cutthroat trout, followed by small mouth bass, kokanee, and perch from Lake Whatcom three or fewer months out of the year. Those that are catching and eating fish are primarily the older segment of the population and primarily males. While few fish consuming households contained children, it was reported that younger children (>8 years of age) eat Lake Whatcom caught fish at the same frequency as the adult household members.

Survey results from the residential, shore, and boat populations suggest that fish meal sizes for locally caught fish is limited by fish size and catch, (i.e., the larger the fish, the larger the size of the fish meal). As an example, median fishmeal sizes for cutthroat trout ranged from 42 to 53 grams per meal across survey samples. Median meal sizes for smallmouth bass ranged from 220 to 330 grams per meal. This difference in meal size is attributable to bass having a larger mass of edible tissue compared to cutthroat trout and not the number of fish consumed per meal. When asked about the typical amount of fish consumed per meal when quantity of fish is not the limiting factor, survey respondents reported consuming an average of 240 grams of fish per meal, with sample population averages ranging from 225 for the residential population to 264 for the boat population. The discrepancy between reported fish meal size based on consumption of locally caught fish verses reported meal size based on the fillet photograph, reinforces the conclusion that angler consumption of Lake Whatcom caught fish is limited by catch and that fish consumers, given an ample quantity of fish, would consume about one half pound (227 grams) of fish per meal. Additionally, these findings suggest that species specific consumption information is necessary to consider when conducting an environmental health assessment.

During the four-week recall period, survey respondents who consume Lake Whatcom fish also reported consuming canned or fresh tuna averaging one meal per week. While this survey did not gather information on the amount of tuna consumed per meal, the frequency with which tuna was consumed by Lake Whatcom fish consumers, and the fact that tuna averages 0.17 mg/kg methylmercury (Yess, 1993), suggests that tuna consumption may be a more significant source of mercury exposure for many local residents than the consumption of Lake Whatcom fish due to tuna consumption frequency.

Responses from this survey suggest that just over half of adult anglers (56 percent) would follow the recommendations of an advisory, if one were issued for Lake Whatcom. Anglers with children on the other hand, indicated they would tend to stop feeding their children any fish from the posted location. Since study results indicate that the frequency with which shore anglers consume Lake Whatcom fish is greater than that of the other groups, health education materials should be designed with this population in mind. Health educators preparing information for Lake Whatcom will be challenged by the preparation of information which results in improving public health through reduced mercury exposure, yet does not create panic causing families to discontinue eating fish. This task will be complicated to an even greater degree given the potential health significance of mercury in canned tuna and the more frequent consumption of tuna relative to fish caught from Lake Whatcom.

The small number of anglers and the small proportion of the residential population that actually consumed any Lake Whatcom caught fish during the four week recall period prior to the survey, limited our ability to fully quantify fish consumption characteristics of the local population, especially women and children. These findings however, indicate that the majority of anglers consume fish from Lake Whatcom at a rate of less than one meal per month and that anglers consume Lake Whatcom caught fish three or fewer months out of the year. This study also identified the presence of a small proportion of anglers that consume fish from Lake Whatcom on a weekly basis and in amounts, which may be sufficient to pose a health risk due to environmental contamination. While reported fish consumption rates, based on the consumption of locally caught fish, reflect rates constrained by external factors, estimates of consumption based on the fillet photo provide a good upper bound rate estimate for conducting exposure analyses.

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APPENDIX A

Lake Whatcom residential fish consumption survey form.

LAKE WHATCOM RESIDENTIAL FISH CONSUMPTION SURVEY

Interviewer: _____ Cluster #: _____ Survey Date: ____/____/00

1. Do you or any member of your family go fishing on Lake Whatcom? Yes No
DK

2. Do you or any member of your family eat fish caught from Lake Whatcom? Yes No
(Skip to 14) DK

Now, I'd like to ask you some specific questions about the fish you eat from Lake Whatcom.

3. For how many years have you eaten fish caught from Lake Whatcom? _____
years (0,1,2,3, etc.)

4. In the **past 4 weeks**, how many times have **you** eaten fish caught from Lake Whatcom? _____
(enter number of meals)

5. Is there a time during the year when **you** eat Lake Whatcom fish more often than this? Yes
No

(If YES, when?

_____)

(Enter Month)

6. **Now I'd like to ask some specific questions regarding your consumption of fish from Lake Whatcom:**

Which Species of Lake Whatcom Fish Do <u>You</u> Consume? ↓ Do you eat.....? (Check all species eaten – show pictures)	How Many Times Have <u>You</u> Eaten This Species During the Past 4 Weeks? (Enter Number)	How Many Fish Do <u>You</u> Typically Eat Per Meal? (Enter Number)	How Many Months Per Year Do <u>You</u> Eat This Species of Lake Whatcom fish? (Enter Number)
(a) Brown Bullhead			_____ mo/yr
(b) Crayfish (Crawdads)			_____ mo/yr
(c) Cutthroat Trout			_____ mo/yr
(d) Kokanee			_____ mo/yr
(e) Perch			_____ mo/yr
(f) Pumpkinseed			_____ mo/yr
(g) Smallmouth Bass			_____ mo/yr

(h) Other: _____			_____mo/yr
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7. **(Display picture of fillet)** During a typical meal, about how much of a fillet like this would you eat?

_____ (Enter number)

8. During the **past 4 weeks**, how many times have you eaten canned or fresh tuna? _____ (Enter number)

9. Who else in your household eats fish from Lake Whatcom? How many...

Men

Women
(18 – 45 y/o)

Women
(>45 y/o)

Child
if n
S.

10. Now I'd like to ask you about your children's consumption of Lake Whatcom fish, starting with your youngest child.

How Old Is This Child? (note if 'months')	Is this child a boy or girl? (record M or F)	How Many Times Has This Child Eaten Lake Whatcom Fish During the Past 4 Weeks? (Enter Number or 'NONE')	During a Typical Meal, About How Much of This Fillet Would They Eat? (Enter line number)	Does This Child Eat This Species of Lake Whatcom Fish as Often as You? (yes/no; if NO, explain)
(a)				
(b)				
(c)				
(d)				
(e)				

Now I'd like to end this survey with a few hypothetical questions. Suppose that local Government issued a health advisory for one species of Lake Whatcom fish, recommending that people should not eat more than, say, 2 meals of this kind of fish per month.

11. First, concerning your children, do you think you would: (*check only one*)

- a) Stop feeding them any fish from Lake Whatcom,
- b) Continue feeding them fish from Lake Whatcom, but make sure to follow all the recommendations, **OR**
- c) Continue feeding them fish from Lake Whatcom without worrying too much about what they eat?

12. Now, concerning your own consumption of Lake Whatcom fish, would you: (*check only one*)

- a) Stop eating any fish from Lake Whatcom,
- b) Continue eating fish from Lake Whatcom, making sure you followed all the recommendations, **OR**
- c) Continue eating fish from Lake Whatcom without worrying too much about what you eat?

13. What would be the best way to get fish consumption advisory information to you? (*Read choices, mark all that apply*)

Posted Signs Fishing Regulations Newspaper Radio Other

_____ DK

14. Demographic Information (for statistical analysis):

(a) Which category best describes your age? (*check only one*) <18 18-45 46-65 66+

Refused

(b) How many people total live at this residence?

(Enter number)

Refused

(c) How many (other) women between the ages of 18 - 45 live in this home?

(Enter number)

Refused

(d) How would you describe your racial/ethnic background? (*Read choices, mark all that apply*)

Caucasian

Hispanic

Native American

African-American

Asian

Other

Refused

(e) Respondent gender: M F

THANK YOU FOR YOUR HELP. WOULD YOU LIKE A COPY OF THE RESULTS OF THIS STUDY?

(If YES, give the respondent a study request card).

APPENDIX B

Salmon fillet photo used during the survey to quantify a typical fish meal size.

Salmon fillet

